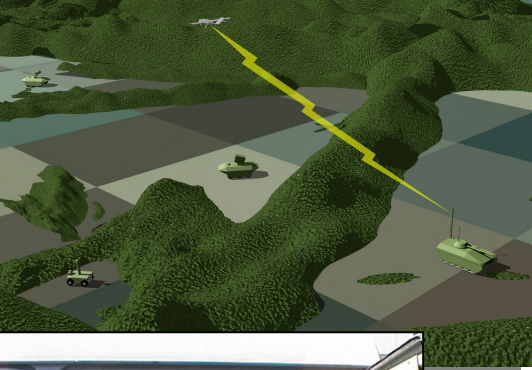


# Collaborative Technology Alliance (CTA)

## Robotics



***Chuck Shoemaker***  
*ARL Collaborative Alliance Manager*

Robotic Systems  
**GENERAL DYNAMICS**

***Scott Myers***  
*Consortium Manager, General Dynamics  
Robotic Systems*



# **Robotics**

## **Collaborative Technology Alliance**



### **Consortium Partners**

- **GD Robotic Systems (Lead)**
- **JPL**
- **BAE Systems**
- **ASI**
- **Micro Analysis & Design**
- **Carnegie Mellon U**
- **U of Maryland**
- **Florida A&M**
- **SRI International**
- **Sarnoff**
- **Science & Engr Sys**
- **PercepTek**
- **Signal Systems**

### **Objectives**

**Develop and evaluate:**

- **Perception technologies enabling semi-autonomous robotic vehicles to maneuver with speed and agility over a wide array of terrain types in varied weather conditions**
- **Intelligent control technology integrating “tactical behaviors” supporting complex sequences of activity appropriate to the tactical situation**
- **Human-machine interfaces enabling effective direction and control of robotic systems while minimizing operator workload**
- **Modeling and simulation technology providing robotics researchers unprecedented ability to design and evaluate new robotic vehicle perceptual capabilities and tactical behaviors responsive to evolving**

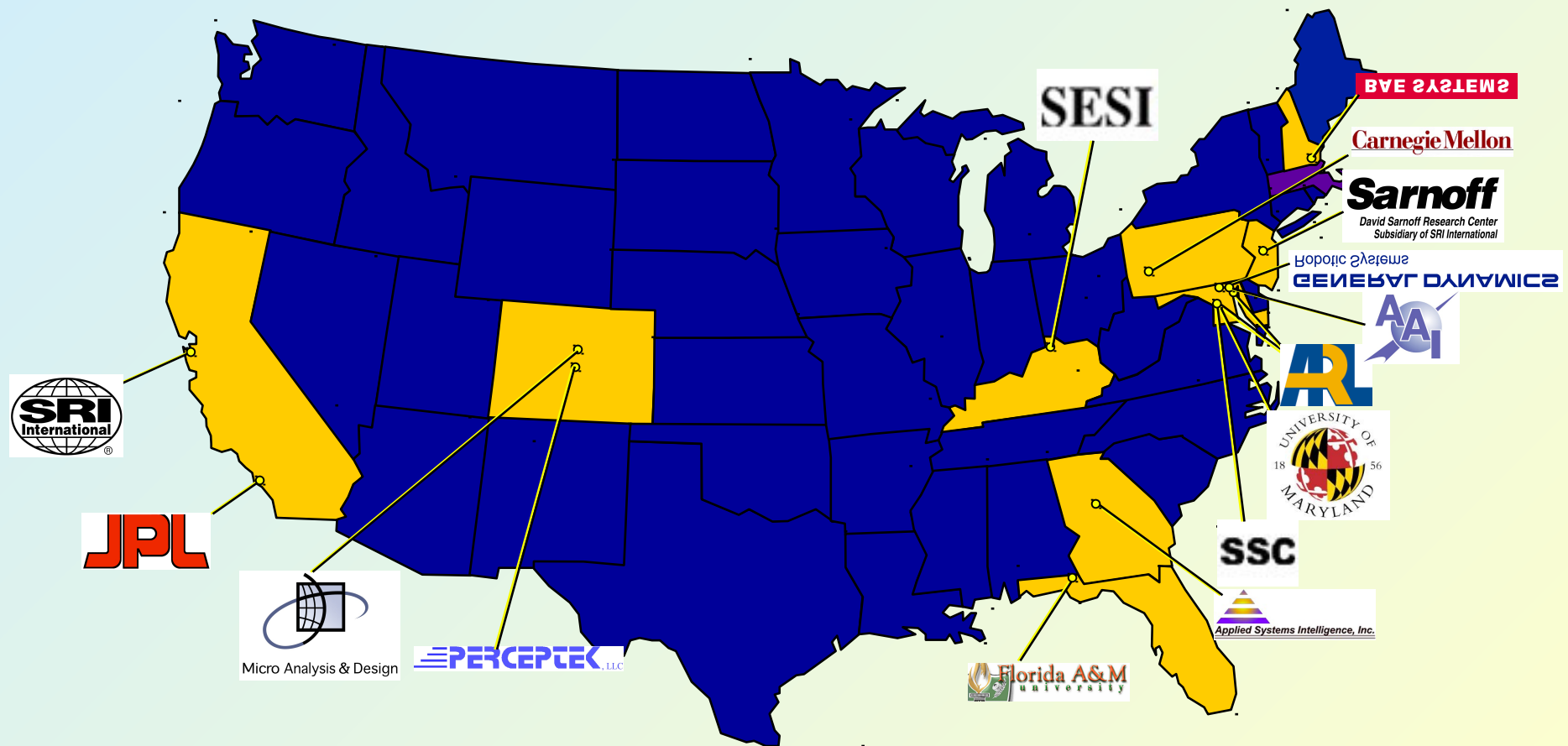
### **Technical Areas**

- **Perception**
- **Intelligent Control & Behaviors**
- **Human-Machine Interface**
- **Modeling, Simulation &**





# Robotics Collaborative Technology Alliance





# Robotics Collaborative Technology Alliance

**PM:** General Dynamics Robotics Systems, Scott Myers

**CAM:** ARL, Charles M. Shoemaker

## Perception

CMU, Dr. Martial Hebert, RTL  
GDRS, Jay Kurtz, ITL  
ARL, Dr. Nasser Nasrabadi

Obstacle Detection &  
Terrain Classification

Road Networks

360° Safeguarding

World Modeling

## Intelligent Control & Behaviors

CMU, Dr. Tony Stentz, RTL  
GDRS, Mark DelGiorno, ITL  
ARL, Stuart Young

Battle Team  
Commander's Associate

Section Level  
Associate

Vehicle & Below

## Human-Machine Interface

MAAD, David Dahn, RTL  
ASI, Dan Rodgers, ITL  
ARL, Dr. Rene dePontbrian

Human Performance  
Assessment

Human Interface

## Modeling, Simulation & Experimentation

GDLS, Bob Otlowski, RTL  
GDRS, Phil Corey, ITL  
ARL, Dr. MaryAnne Fields

Constructive  
Simulations

Engineering  
Models

Virtual  
Simulations

Field  
Experimentation



# Army Robotics Research Program



***Rapidly advance ground robotics technology  
for Objective Force applications***

- **Focused research:**
  - Perception
  - Intelligent control
  - Soldier-robot interface
- **Field Experience:**
  - Conduct early & continuous field tests
  - Promote troop interaction to focus research & foster parallel TTP development
- **Technology Testbed:**
  - Develop multiple approaches now & down select later
  - Provide infrastructure to foster rapid technology advancement
- **Rapid Transition**
  - Demonstrate potential applications as appropriate autonomous mobility capabilities are achieved
- **Work with other agencies:**
  - Leverage other Government efforts (NASA, NIST, DOE, DARPA)
  - Partner with Industry & Academia
    - Robotics Collaborative Technology Alliance



***Autonomous Land Navigation  
for multiple Objective Force missions***

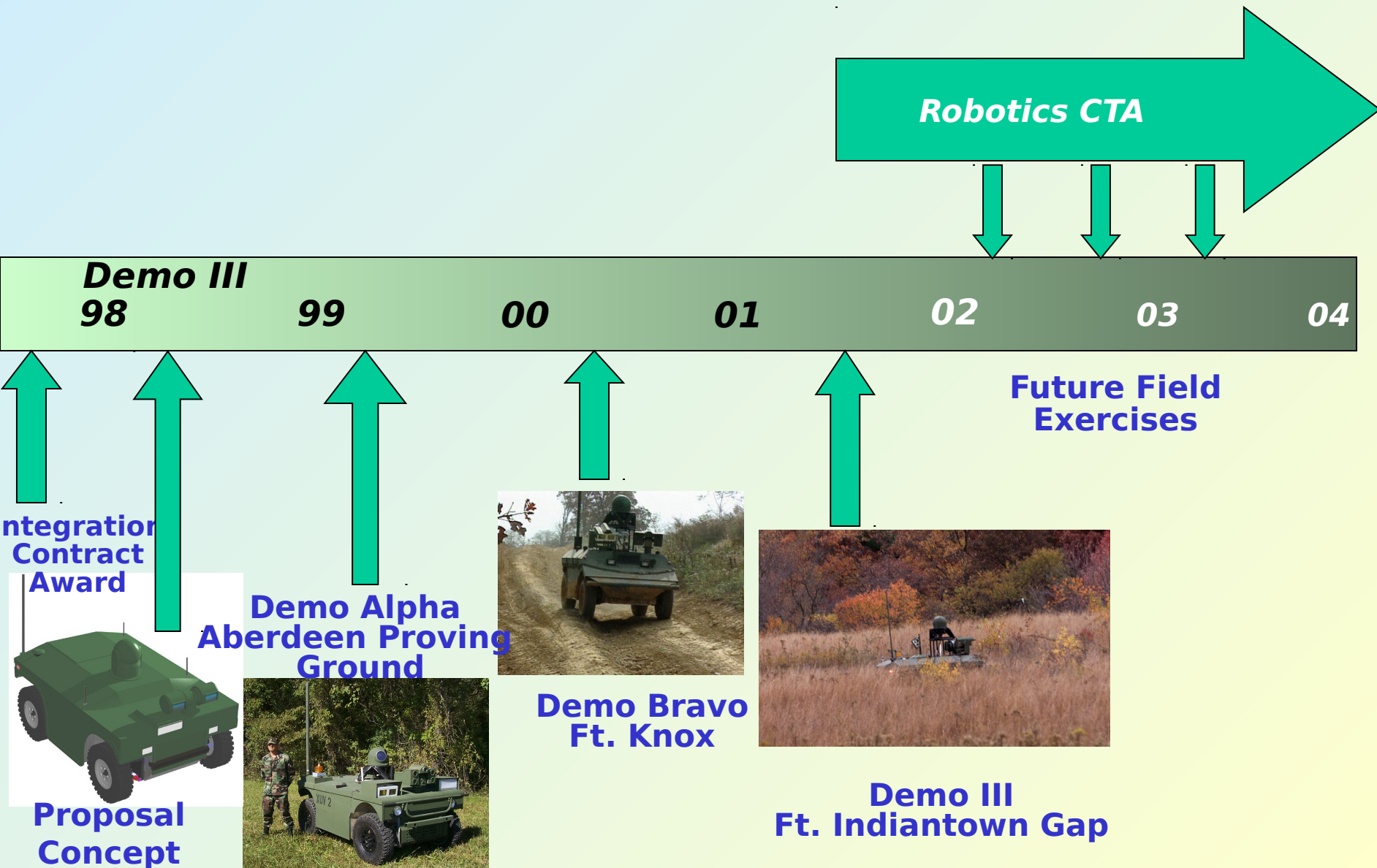
# ***Infrastructure for rapid technology development***





# Army Robotics Research Program

## CTA Key to Technology Advancement



# ***Demonstration Video***





# Robotics CTA

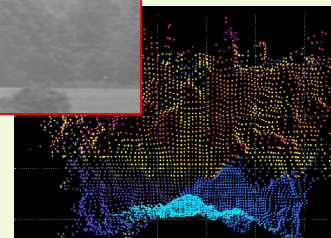
## Advanced Perception



**Objective:** Robust, reliable short-range perception enabling vehicles to maneuver with speed and agility over a wide array of terrain types in varied environmental conditions, complemented by highly capable mid-range perception for tactical mobility planning and mapping of the environment

### Challenges:

- Understanding the local environment
  - Reliably detect all mobility obstacles
  - Determine trafficability
  - Detect features of tactical interest
- Model large terrain features to aid in navigation planning
- Cluttered & mixed environments



### Research Tasks:

- Obstacle Detection & Terrain Characterization
- Fusion and Registration
- Road Networks
- 360° Safeguarding
- World Modeling





# Robotics CTA

## Intelligent Control Architectures

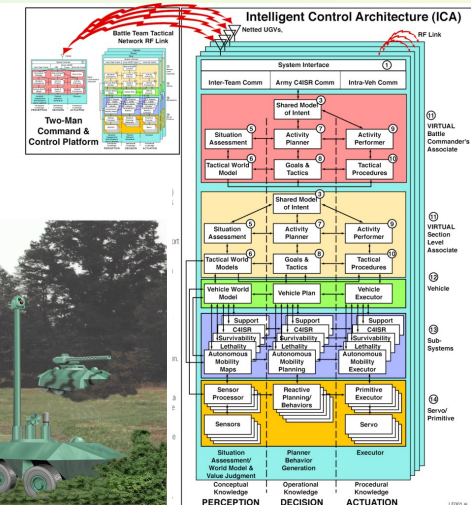
**Objective:** Intelligent control technology integrating “tactical behaviors” supporting complex sequences of activity appropriate to the tactical situation

### Challenges:

- World modeling and mapping
- Task definition and decomposition
- Multi-vehicle coordination and cooperation
- Symbolic & geometric planning
- Tactical behaviors
- Contingency handling

### Research Tasks:

- Development and implementation of architecture
- Integration of tactical behaviors
- Multi-vehicle planning & coordination
- Detection & tracking of people
- Geometric planning
- Fault detection and isolation - robust





# Robotics CTA

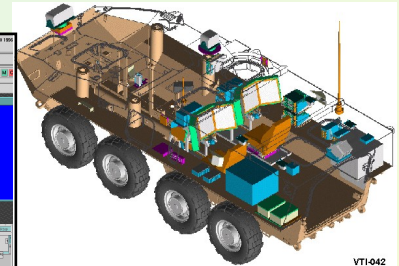
## Human-Machine Interfaces



**Objective:** Human-machine interfaces enabling effective direction and control of robotic systems while minimizing operator workload throughout the anticipated range of mission profiles, stressor conditions, soldier aptitude and battlefield intensity levels

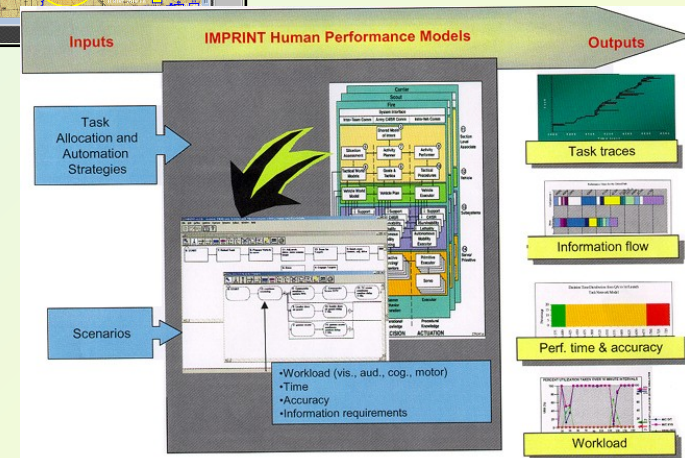
### Challenges:

- Optimal workload distribution between soldier and robot - prevention of cognitive overload
- Changes in HMI to support different operator roles, levels of autonomy, reliability of system
- Optimal information transmission
- Soldier trust



### Research Tasks:

- Multi-modal soldier-machine interface
- Multi-modal interaction modeling
- Human interface for geometric planning
- Fusion and Registration
- Human performance assessment of baseline system
- Workload theory
- Trust in Automation
- New OCU performance models





# Robotics CTA

## Modeling, Simulation & Experimentation



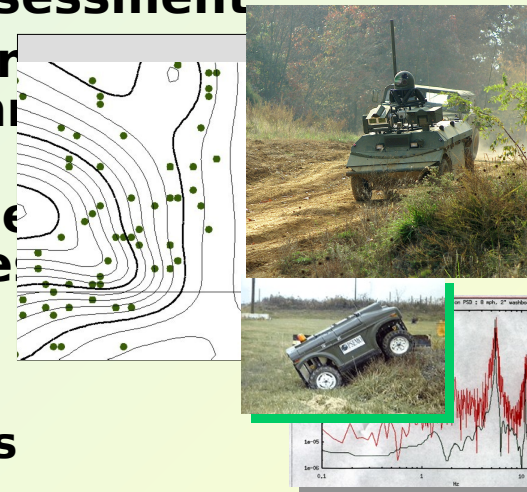
**Objective:** Modeling and simulation technology providing robotics researchers unprecedented ability to design and evaluate new robotic vehicle perceptual capabilities and tactical behaviors responsive to evolving operational needs

### Challenges:

- Creation of an accurate synthetic environment for rapid technology development and assessment
- Virtual environments for human performance assessment over a wide range of environmental span of control, and battlefield tempo
- Technology assessment over a broad range of operational conditions to assure robustness and reliability

### Research Tasks:

- OneSaf vignette development and task analysis
- UAV/UGS OneSAF
- Technical simulation for associate system research
- Field experimentation for characterizing obstacle detection
- UAV data geo-registration
- End to end robot testing
- Establishment of FAMU Mobile Robotics Lab

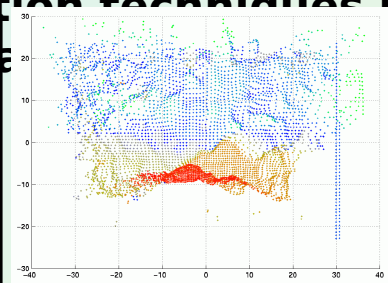




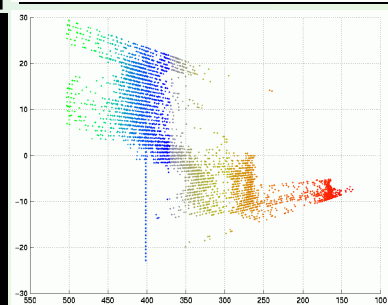
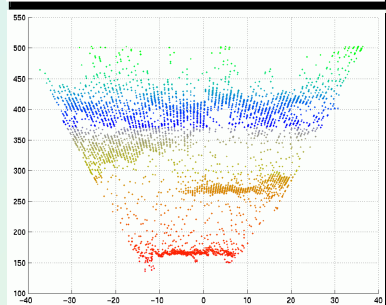
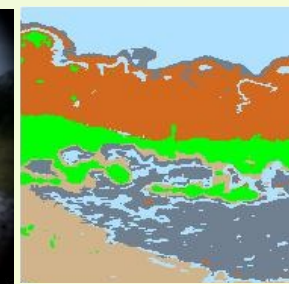
# Advanced Perception

## FY01/02 Notable Achievements

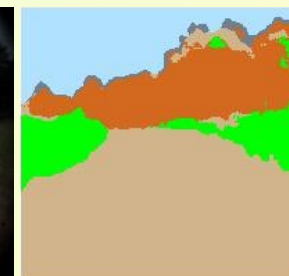
- **Passive techniques for mid-range sensing:**
  - Development of structure from motion and cooperative stereo techniques for mid-range ( $> 100\text{m}$ ) sensing - ready for transition to XUVs.
- **Mapping and localization:**
  - Initial demonstration of site mapping using AUV (helicopter)
  - Development of new AUV mapping facilities for CTA
  - Localization techniques using feature and map matching



← **Mid-range sensing**



**Terrain Classification** →





# ***Advanced Perception FY01/02 Notable Achievements***



- **Passive sensing for obstacle detection**
  - 15 Hz passive ranging imaging, obstacle detection, and terrain classification on a single VME board, day or night using CCD and FLIR stereo
- **Terrain classification**
  - Terrain classification software running with color cameras, LADAR, and FLIR - off line training will treat progressively more complexity terrain data set
  - Ready for transition to XUVs
- **360° Safeguarding**
  - Real time algorithms for detection and tracking of isolated people from stationary camera.
  - Progress toward extension to panning cameras and groups - initial tr
  - Laser sensor - New no-moving-parts range finder for short-range 360 surround sensing
  - Acoustics - Field experiments demonstrate potential for acoustic detection at tactically significant ranges on-board unmanned vehicles with platform reduction technology.



# ***Intelligent Control Architecture FY01/02 Notable Achievements***

- **Initial CTA intelligent control architecture defined and designed**

- Battle team (platoon level) components and tactical behaviors defined -

- Section Level Associate developed for Demo III - implementation

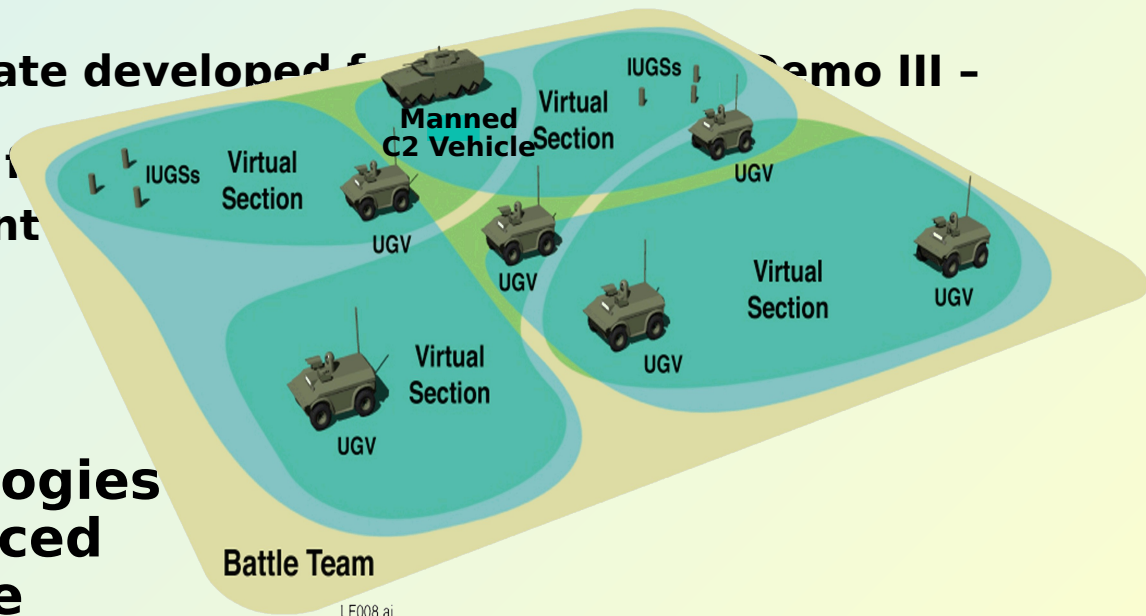
- of tactical behaviors

- Basis for development technologies for TARDEC CAT ATD

- **Component technologies extended for advanced vehicle performance**

- dynamic, real-time geometric planning to find routes that optimize a cost metric (e.g., mobility, risk, stealth) while satisfying a constraint (e.g., arrival time)

- multi-vehicle planning and coordination for tasks such as





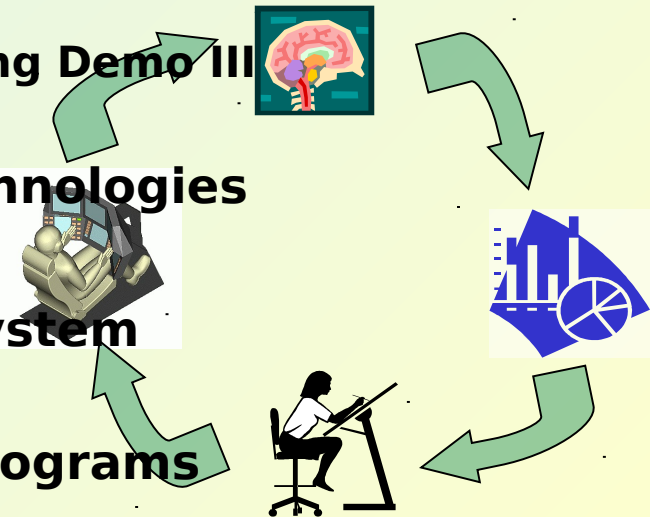
# ***Human-machine Interface***

## ***FY01/02 Notable Achievements***



### **Development of new Soldier-robot interface - control of multiple unmanned assets:**

- **Definition of baseline requirements for controlling and using unmanned assets**
  - **Collection of soldier performance data during Demo III field exercise**
- **Investigation of multi-modal interface technologies**
  - **Evaluation of speech recognition systems**
- **Human performance modeling for multi-system UGV employment**
- **Application to Demo III and TARDEC VTI programs**





# ***Modeling, Simulation & Experimentation***

## ***FY01/02 Notable Achievements***

- **Developed scenarios to be used in the CTA program to provide an operational context for robotic technology development.**
  - Detail down to the platoon level op-order.
  - Armor Center involvement in scenario development
- **Initiated task decomposition based on the scenarios**
- **Plan to develop & implement a common CTA simulation environment based on OneSAF to:**
  - Develop and analyze Intellegent Command and Control structures
  - Develop and design effective human machine interfaces.
- **Developed a functional description of Unattended Ground**

Scenarios for OneSAF



# ***Other Accomplishments***



- ***Workshops***

- ***Intelligent Architectures/Human-machine Interface***

- ***23-25 October - Westminster, MD***
    - ***27-28 March - Westminster, MD***

- ***Advanced Perception***

- ***3-4 December - ARL Adelphi, MD***

- ***FAMU Robotics Laboratory***

- ***Developed common interfaces for insertion of component technology into Demo III XUV***

- ***Advanced perception components***
  - ***Geometric planning components***

- ***Extended visualization tools for evaluation of component technology***

- ***Technology transition to the Demo III and TARDEC Vetrionics Technology Integration (VTI) Programs***

- ***Task Order Contracts***

- ***Navy EOD Technology Division***
  - ***Unmanned Ground Vehicle/System Joint Program Office***



# ***Robotics CTA***

## ***Milestones & New Directions for FY03***



- **Transition technology components onto XUV and evaluate for incorporation into Demo III Field Exercises**
- **Perception:**
  - **Near-field - extend perception to thin objects such as wire; temporal integration of LADAR data**
  - **360° Safeguarding - Detection of looming threats, human activity identification, integration of safeguarding sensors on XUV, fusion and visualization of video streams from multiple moving sensors**
  - **Mid-range sensing - Mapping and localization from omnidirectional sensor data; matching with feature data**
- **Intelligent Control Architectures:**
  - **Implementation of Battle Commander Associate & Section Leader Associate tactical behaviors**
- **Soldier-machine Interface:**
  - **Explore and Ensure Consistent Op Tempo Perception Within and Across Soldier-Robot Teams**
  - **Enhance Theoretical, Analysis, and Applications Models to Assess Role of Trust**
- **Modeling, Simulation & Experimentation:**
  - **System level performance measurements**
  - **Common simulation environment**